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A Novel Protocol Design in Hybrid Networks of Visible Light Communication and OFDMA System

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***Abstract*—In recent years, visible light communication (VLC) has emerged as a complementary technique to overcome limitations of the crowded radio frequency (RF) spectrum. Its superior characteristics include unlicensed wide bandwidth, high security and dual-use nature. VLC can transmit 4Mb/s in short distance. However VLC using illumination sources is naturally suited to broadcast applications, providing an uplink to the distributed transmitter structures can be problematic. In order to alleviate this problem a protocol has been proposed combined with horizontal and vertical handover mechanisms for mobile terminal to resolve user mobility among different VLC hotspots and orthogonal frequency division multiple access(OFDMA) system, in which VLC is used for downlink transmission and OFDMA for uplink transmission .A new VLC network scheme and its frame format are also presented to deal with the multiuser access problems in every hotspot.**

***keywords*—heterogeneous network, horizontal handover, vertical handover, hybrid visible light communication(VLC) and orthogonal frequency division multiple access (OFDMA) system, visible light communication.**

I. INTRODUCTION

Due to drastically growing commercial demands of wireless access services, available RF bandwidth is getting exhausted. As a result of severe congestion in the RF shared medium, network performance decreases sharply with contention and interference. This phenomenon is called the "spectrum crunch" problem . For the sake of satisfying future requirements of individual users or enterprise groups,
novel approaches capable of providing the aggregate capacity to serve more users need to be developed.

VLC technology, with its superior characteristics including high area spectral efficiency, unlicensed wide bandwidth, high security and dual-use nature, emerges as a complementary technique. Fig. 1 compares a) an RF channel in which three users share the 20Mb/s bandwidth, to b) a VLC-enabled environment in which three users utilize individual 10Mb/s VLC channels, providing 10Mb/s more aggregate bandwidth than the individual RF channel. As a complementary approach to the existing wireless RF solutions, VLC is poised to overcome the crowded radio spectrum in highly-localized systems and become a promising broadband wireless access candidate to resolve the "spectrum crunch" problem.

The LED-based indoor VLC has attracted great attention in recent years due to its innate physical properties including energy efficiency and lower operational cost compared to old incandescent and fluorescent lighting . Current works on VLC focus mainly on the physical (PHY) layer techniques, such as dimming support, flicker mitigation, and advanced modulation schemes. The primary goal of PHY layer research is to enhance data rates within the constraints of VLC, which includes short range coverage, dimming control, flicker insensitive to human eyes, etc. Based on the PHY layer efforts, researchers have begun to investigate the higher layer techniques required for practical VLC networking .

Although dual-use VLC integrates data communication and illumination functionalities, the uplink mechanism comes to be a non-negligible issue for VLC networking. In electromagnetic-sensitive and high-level security applications, uplink VLC is possible with relatively high transmission speed.However, in most electromagnetic-insensitive places such as home, school, office, supermarket, VLC is unsuitable for uplink in practical scenarios. The reasons are as follows: i) Mobile devices (i.e. labtop, smart phone, tablet) are energyconstrained. Equipping these devices with a light source strictly for communications costs large amounts of power, which makes uplink VLC a challenging problem. ii) Uplink VLC with narrow beam-width requires transmission beam to be orientated to a fixed direction. Slight movement or rotation could significantly affect throughput, which is unsuitable for mobile devices.

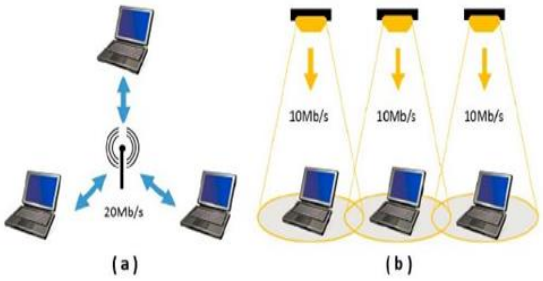

Figure 1: Bandwidth density of (a) RF and (b) VLC 3

iii) Uplink visible signals can affect the indoor illumination and cause discomfort to human eyes. Taking these inconvenient aspects into consideration, VLC is ideally suited as a complementary downlink-only technology within a heterogeneous network.

Hence a protocol has been designed in which OFDMA is used for uplink and VLC for downlink to resolve multiuser mobility.

A. Related Work

Early work shows that VLC has several superiorities over the RF system in indoor scenarios, but still there are some challenging tasks still need to be resolved. First, VLC using illumination sources is naturally
suited to broadcast applications, and providing an uplink to the distributed transmitter structures can be problematic. Wang et al. demonstrated a high-speed full-duplex indoor optical wireless communication system, but it cannot operate without optical wireless localization technology. More-over, IR technologies are usually used for the uplink, but it can be easily blocked and result in instability of the system. Second, a VLC receiver must direct to the transmitter in order to trace the optical signal. Therefore, VLC links can be lost due to movement or rotation of the receiver. It is necessary to have link recovery and handover mechanisms at mobile scenarios, yet this is still an open topic. Third, the VLC coverage is constrained within the opaque space, which is different from the characteristics of RF. As a result, seamless coverage can be problematic.

In order to overcome the disadvantages of VLC technology,combination schemes of VLC and RF, in indoor scenarios, have been presented in recent literature . Hou and O'Brien proposed a fuzzy-logic (FL)-based decision-making algorithm for vertical handover in the integrated system of optical wireless and RF technologies. In this system, the optical linkis subject to blocking, and depending on the duration of the blocking, the system performs a vertical handover to an RF LAN. Rahaim et al. proposed an indoor hybrid system that integrates WiFi and VLC luminaries in which VLC is only used for broadcasting. A simplified vertical handover mechanism was presented, and the downlink throughput in three cases:1) utilizing only the WiFi channel; 2) all downlink traffic is operated by VLC; and 3) transfer to VLC channel using the simplified handover mechanism once WiFi channel has reached its capacity have been analyzed. However, user mobility has not been considered; thus, access and horizontal handover protocols were not proposed in previous work . In few research work,an RF signal is used for subscriber localization, and optical signal, including uplink and downlink, is then directed to that known position of the subscriber with steering mirror for high-speed data transmission. Nevertheless, the RF system is a supplementary network for tracing the subscriber rather than for increasing the system capacity, which is the same as in [7]. In this paper, we propose a hybrid VLC-OFDMA network model that consists of M VLC hotspots, one access point (AP) of OFDMA system[e.g., Long Term Evolution (LTE) base station or Worldwide Interoperability for Microwave Access (WiMax) AP], one server,
and numbers of mobile terminals (MTs). AP and VLC hotspots are linked to the server via wired connections. In this model,VLC channel is only used for downlink transmission, whereas OFDMA channels are served for uplinks in any situation or for downlinks only without hotspots coverage. Our model can be implemented in places where an OFDMA system (e.g., LTE or WiMax network) cannot accommodate large numbers of users(e.g., hotels and large conference halls).

The contributions made in this paper are twofold. First, we propose a novel protocol combined with access, horizontal, and vertical handover mechanisms for MT. Unlike previous studies,we take into account the mobility of MTs, thus triggering the horizontal handover mechanism to keep VLC connection stable whenever MT moves among different hotspots and to operate the vertical handover protocol whenever MT moves on the edge of VLC and OFDMA systems. Second, a new VLC network scheme and its frame format are presented. A unique ID is allocated for every VLC hotspot to make the server localize MT to trigger the appropriate handover mechanism.

II.SYSTEM MODEL

Consider hybrid system model consisting of M VLC hotspot and one Access Point(AP) of OFDMA system which are linked to the server using wired connection.

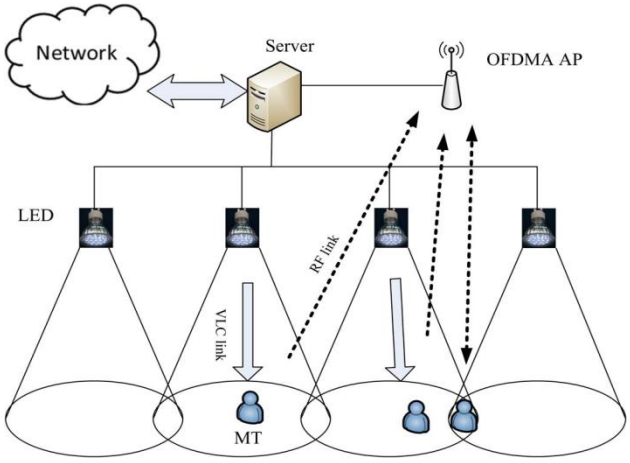

Fig. 2.System Architecture

The VLC hotspot, which is mounted on the ceiling of the room, contains an array of LEDs as transmitters and also for illuminations .The projection of a hotspot on the ground can
be regarded as a circle. The server has knowledge of the locations and unique IDs of all hotspots. It receives feedback from MTs if they access the coverage of hotspots. The feedback information from MTs includes the received ID segment of the covered hotspot and the received light intensity. The server locates MT by decoding the ID segment and allocates the download transmission to the designated hotspot or AP. MTs moving across the room will trigger the horizontal handover among different VLC hotspots or the vertical handover between VLC and OFDMA systems.

A.Protocol

The protocol presented in this paper are designed based on the system architecture.As shown in Figure 3 Mobile terminal apply for the uplink channels via the control channels of OFDMA system. We set Timer 1 to avoid endless loop in the applying process. Once this process fails,MTs cannot access a VLC or OFDMA network. If it succeed user can upload the ID segment.

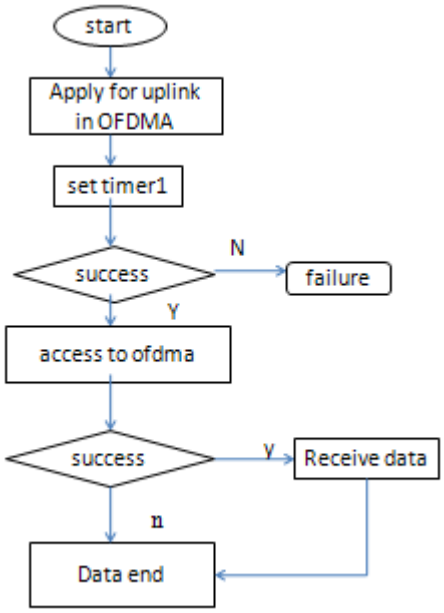

Fig. 3.Uplink channel

As shown in Figure 3 and 4 the process of accessing to VLC system can be divided into three parts: 1) MT applies for the uplink in OFDMA system; 2) after detecting VLC signal, MT uploads the ID segment of the hotspot and the light channel conditions via OFDMA network to the server; and 3) the server locates the hotspot served for the MT and broadcasts the slot allocation packets through the light channel. After receiving them success-fully, MT accesses to VLC systemif MTs enter into the coverage of hotspots, they wait until receiving the head of one frame of VLC packet. Then, they upload the received ID segment and light channel conditions to the AP via the uplink channels. Timer 2 is set to limit the waiting time to access the VLC system. If the waiting time is larger than the value of Timer 2, MTs switch to OFDMA system.

The horizontal handover emerges when MTs cross one hotspot to another. In Fig. 4, after waiting for random duration, MT uploads a new ID segment and channel conditions if it enters into new hotspot coverage via receiving a refreshed ID segment, although Timer 2 is out. Based on this, horizontal handover is accomplished. However,vertical handover will replace the horizontal handover if MT cannot yet receive slot allocation information after waiting random duration and Timer 2 is out simultaneously.

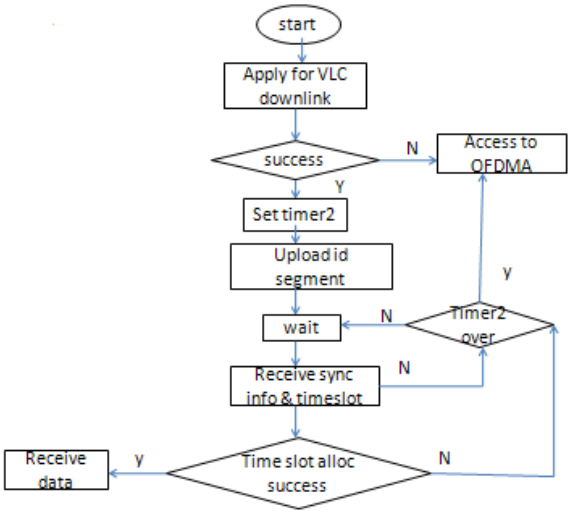

Fig. 4.Downlink channel

III.SIMULATION

The vertical and horizontal handover mechanism is depicted using simulation of 47 nodes.Here to accomplish handover mechanism three access technologies are considered eg:UMTS,WiMax,Wi-Fi.As shown in Figure 5 45,46,47 are considered as sink node.

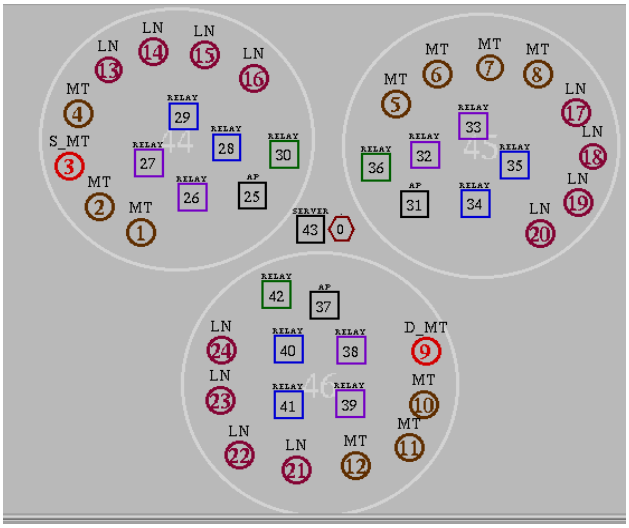

Fig. 5.System model

As explained in system architecture the system model has one server and access point and three sink node with mobile node and landline terminal.

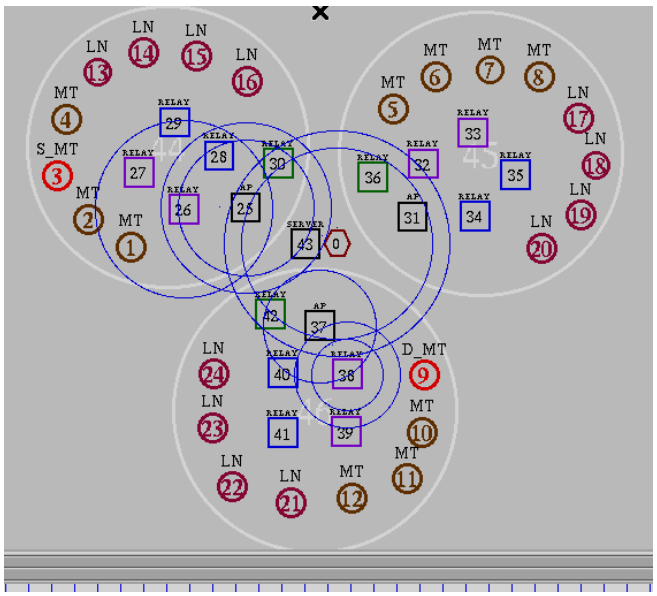

Fig. 6.Vertical Handover

Vertical handover mechanism take place when mobile node need to communicate with other node in different access technology.As shown in Figure 6 AP in source node check the received signal strength of the node and the OFDMA AP locate the destination node using server then the communication begins between the MTs.

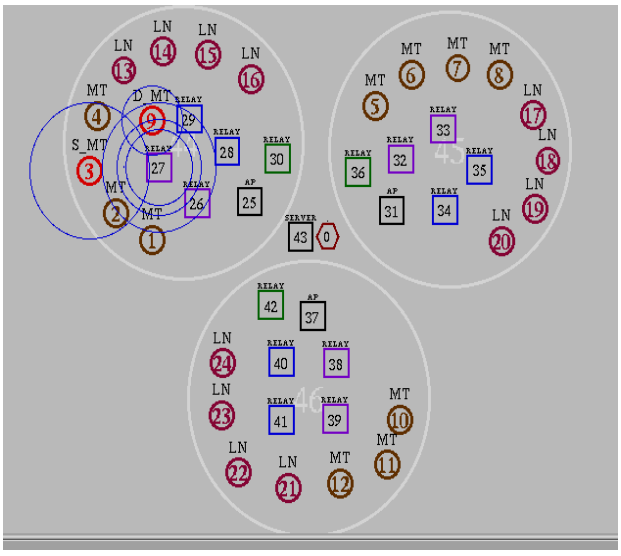

Fig. 7.Horizontal Handover

Horizontal handover take place between same access technology.In both the method multihop cellular IP protocol method has been used to relay the message between source and destination. In Hybrid adhoc network each node will communicate with other nodes, with the control of Base station and Accounting center or access point which act as a gateway node. The direct

communication is not possible in hybrid network. The AC (accounting center) should verifies the caller accessibility and depending on that it will decide further proceed or not. The Base Station and AC should communicate via WLAN.

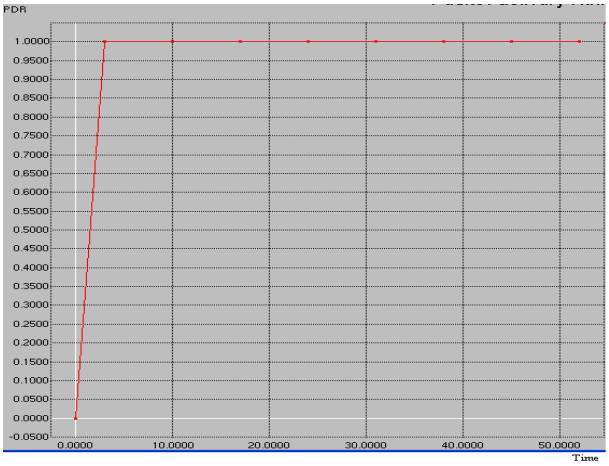

Fig. 8.Packet Delivery Ratio

As shown in Figure 8 and 9 the packet delivery ratio and throughput increases when compared to other hybrid combination methods.

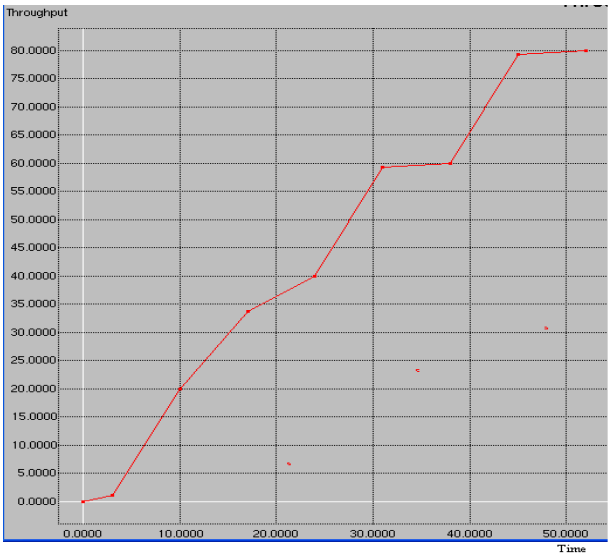

Fig. 9.Throughput

V.CONCLUSION

In this paper ,user requirements are growing faster than ever and the limitations of the current mobile communication systems have forced the researchers to come up with more advanced and efficient technologies. It is supposed to provide its customers with better speed and all IP based multimedia services hence Multi hop cellular ip MCIP is all about an integrated, global network that will be able to provide a comprehensive IP solution where voice, data and streamed multimedia can be given to users on an "Anytime, Anywhere" basis. In this model, the VLC channel is only used for downlink transmission, whereas OFDMA subchannels are served for uplinks in any situation or for downlinks only without hotspots coverage. A novel protocol
is presented combined with access, horizontal, and verticalhandover mechanisms for MT to resolve user mobility among different hotspots and OFDMA systems.

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